

**NASA/TP-20220005381**



# **Wallops Flight Facility Integration and Testing Customer Handbook**

---

**May 2022**

## NASA STI Program ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA scientific and technical information (STI) program plays a key part in helping NASA maintain this important role.

The NASA STI program operates under the auspices of the Agency Chief Information Officer. It collects, organizes, provides for archiving, and disseminates NASA's STI. The NASA STI program provides access to the NTRS Registered and its public interface, the NASA Technical Reports Server, thus providing one of the largest collections of aeronautical and space science STI in the world. Results are published in both non-NASA channels and by NASA in the NASA STI Report Series, which includes the following report types:

- **TECHNICAL PUBLICATION.** Reports of completed research or a major significant phase of research that present the results of NASA Programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.
- **TECHNICAL MEMORANDUM.** Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- **CONTRACTOR REPORT.** Scientific and technical findings by NASA-sponsored contractors and grantees.

- **CONFERENCE PUBLICATION.** Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.

- **SPECIAL PUBLICATION.** Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.

- **TECHNICAL TRANSLATION.** English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services also include organizing and publishing research results, distributing specialized research announcements and feeds, providing information desk and personal search support, and enabling data exchange services.

For more information about the NASA STI program, see the following:

- Access the NASA STI program home page at <http://www.sti.nasa.gov>
- E-mail your question to [help@sti.nasa.gov](mailto:help@sti.nasa.gov)
- Phone the NASA STI Information Desk at 757-864-9658
- Write to:  
NASA STI Information Desk  
Mail Stop 148  
NASA Langley Research Center  
Hampton, VA 23681-2199

**NASA/TP-20220005381**



# **Wallops Flight Facility Integration and Testing Customer Handbook**

*Wallops Flight Facility, Wallops Island, VA*

National Aeronautics and  
Space Administration

Goddard Space Flight Center  
Greenbelt, Maryland 20771

---

**May 2022**

Trade names and trademarks are used in this report for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

*Level of Review: This material has been technically reviewed by technical management.*

National Aeronautics and Space Administration



# Wallops Flight Facility Integration and Testing Customer Handbook

**NASA Goddard Space Flight Center  
Wallops Flight Facility  
Wallops Island, Virginia 23337**

## TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION.....</b>	<b>7</b>
1.1	Purpose .....	7
1.2	Facility History.....	9
1.3	Wallop Main Base Overview .....	9
1.4	Overview of Wallops Island .....	11
<b>2</b>	<b>ELECTRICAL INTEGRATION AND TESTING.....</b>	<b>12</b>
2.1	EMI/EMC Measurement Facility (Building F-7).....	12
2.2	Anechoic Chamber Facility (Building F-7).....	12
2.3	GPS Simulation Lab Facility (Building E-109) .....	14
2.4	Radar Lab Facility (Building E-109).....	14
2.5	Microwave Lab Facility (Building E-109).....	15
2.6	Electrical Lab (Building E-109) .....	16
2.7	Telemetry Ground Stations (Building F-10).....	17
<b>3</b>	<b>MECHANICAL INTEGRATION &amp; TESTING .....</b>	<b>18</b>
3.1	Thermal Chambers (Building F-7).....	18
3.2	Thermal Chambers (Building F-10).....	20
3.3	CSBF Thermal Vacuum Facility .....	22
3.4	Environmental Test Chamber (Building E-109) .....	24
3.5	Vibration Test Facilities (Building F-10) .....	25
3.6	Vibration Test Facilities (Building E-109) .....	26
3.7	Balancing Machines (Static and Dynamic) (Building F-10) .....	27
3.8	Mass Properties Measurement System (Building F-10) .....	27
3.9	Spin Deployment Facility (Building F-10) .....	29
3.10	Bend Test Facility (Building F-10).....	30
<b>4</b>	<b>PAYOUT FABRICATION, INTEGRATION &amp; TESTING .....</b>	<b>31</b>
4.1	Payload Fabrication (Building F-10).....	31
4.2	Attitude Control System Testing (Building F-10) .....	32
4.3	Sounding Rocket Payload Integration (Building F-10).....	33
4.4	Solar Simulator (Building E-109) .....	34
4.5	SmallSat and Balloon Payload Integration (Building F-7).....	35
4.6	Payload Processing Facility (PPF).....	36
4.7	SmallSat Multi-Payload Processing Facility (Building F-7).....	36
4.8	Rideshare Mission Integration Services (Building F-7) .....	37
4.9	High Bays (Building E-109).....	38
4.10	High Bay East (Building F-7).....	39
4.11	High Bay West (Building F-7).....	40
4.12	Balloon Research and Development Laboratory (Building F-7) .....	41
<b>5</b>	<b>ENGINEERING SUPPORT .....</b>	<b>42</b>
5.1	Overview .....	42
5.2	Mission Planning Lab (Building E-109) .....	42
5.3	Interconnect Lab (Building E-109).....	42
5.4	Prototype Lab (Building E-109).....	43
5.5	3-D Printer (Building E-109).....	44
5.6	Machine Shop (Building E-109).....	44
5.7	Software Development (Building E-109).....	45
<b>6</b>	<b>OTHER SUPPORT SERVICES .....</b>	<b>46</b>
6.1	Assembly and Processing Facilities .....	46
6.2	Aircraft Operations Hangar (Building D-1) .....	47
6.3	Aircraft Hangar (Building N-159) .....	49
6.4	MARS/VCSFA .....	50

6.5	UAS Airfield .....	51
6.6	MARS Payload Processing Facility .....	54
6.7	MARS Port .....	55
6.8	Mission Operations Control Center (MOCC) .....	55
6.9	Integration and Control Facility.....	56
	<b>APPENDIX A: ABBREVIATIONS AND ACRONYMS.....</b>	<b>57</b>

## LIST OF FIGURES

Figure 1: Main Base and Airfield .....	10
Figure 2: Launch Range.....	10
Figure 3: Main Base and I&T Building Locations.....	11
Figure 4: Wallops Island.....	11
Figure 5: EMI/EMC Measurement Facility .....	12
Figure 6: Anechoic Chamber Facility Az/El Positioner Tower .....	13
Figure 7: Anechoic Chamber Facility Compact Range Source Feed.....	13
Figure 8: Anechoic Chamber Facility Compact Range Reflector.....	13
Figure 9: Anechoic Chamber Facility Far Field Source Feed.....	13
Figure 10: GPS Simulator Lab.....	14
Figure 11: Flight Termination Receiver System Certification Bench.....	14
Figure 12: Test Equity Model 115 Thermal Cycle Chamber.....	15
Figure 13: Microwave Lab Facility .....	15
Figure 14: Microwave Lab Facility .....	16
Figure 15: Agilent 8722ES Network Analyzer.....	16
Figure 16: Electrical Lab (Building E-109) .....	16
Figure 17: Telemetry Ground Station .....	17
Figure 18: Thermal Vacuum Chamber .....	18
Figure 19. Thermal Vacuum Chamber Ports .....	18
Figure 20: Thermal Vacuum Chamber .....	18
Figure 21: Thermal Vacuum Chamber used for small spacecraft, subsystems, and components .....	19
Figure 22. Thermal Vacuum Chamber used for testing Balloon High Gain Antenna (HGA).....	19
Figure 23: Thermal Chamber (Building F-7).....	20
Figure 24. Thermal Vacuum Chamber (Building F-10) .....	20
Figure 25: PV/T Vacuum Chamber .....	21
Figure 26: Altitude Bell Jar.....	21
Figure 27: Espec ESZ-4CA Thermal Chamber .....	22
Figure 28: CSBF Thermal Vacuum Chamber.....	23
Figure 29: Environmental Test Chamber Model T5ST .....	24
Figure 30: Vibration Table.....	25
Figure 31: Unholtz Dickie (UD) Small Chamber .....	25
Figure 32: Vibration Test.....	26
Figure 33: Balancing Machine.....	27
Figure 34: Mass Properties Measurement System.....	27
Figure 35: Mass Properties Measurement System.....	28
Figure 36: Mass Properties Measurement System .....	28
Figure 37: Mass Properties Measurement System .....	29
Figure 38: Spin Deployment Facility.....	29
Figure 39: Bend Test Fixture .....	30
Figure 40: Fabrication Facility.....	31
Figure 41: Fabrication Facility.....	31
Figure 42: Magnetic Calibration Facility.....	32
Figure 43: Magnetic Calibration and Testing .....	33
Figure 44: Payload Integration and Testing .....	33
Figure 45: Payload Integration and Testing .....	34
Figure 46: E-109 Solar Simulator .....	34
Figure 47: Integration and Test (Building F-7).....	35
Figure 48: Integration and Test (Building F-7).....	35
Figure 49: Building F-7 Supplemental Integration Workspace .....	35

Figure 50: Payload Processing Facility.....	36
Figure 51: SmallSat Lab .....	36
Figure 52: SmallSat Lab .....	37
Figure 53: Supplemental Integration Workspace.....	37
Figure 54: Landsat 9 Integration.....	37
Figure 55: Integrated ESPA ring prior to leaving Wallops (Building F-7).....	38
Figure 56: EFS Assembly Stand .....	38
Figure 57: Building E-109 High Bays .....	38
Figure 58: High Bay East Cleanroom Tent with ESPA ring integration ground support equipment in the foreground.....	39
Figure 59: High Bay East Cleanroom .....	39
Figure 60: High Bay West .....	40
Figure 61. Balloon Research and Development Lab .....	41
Figure 62. Balloon Research and Development Lab Mechanical Testing Facilities .....	41
Figure 63: Wallops Arc Second Pointer (WASP).....	42
Figure 64: Interconnect Lab (Building E-109) .....	43
Figure 65: Prototype Lab (Building E-109) .....	43
Figure 66: E-109 3-D Printer .....	44
Figure 67: Aircraft Operations Hangar (Building D-1) .....	47
Figure 68: Aircraft Operations Hangar (Building D-1) .....	47
Figure 69: Aircraft Operations Hangar (Building D-1) .....	48
Figure 70: The Northrop Grumman Antares vehicle, on its way to the commercially operated MARS launch pad .....	50
Figure 71: MARS UAS Airfield .....	51
Figure 72: 3000-foot x 75-foot UAS Runway .....	51
Figure 73: Concrete VTOL Pad rated to 5000 psi .....	51
Figure 74: MARS UAS Airfield HVAC Conditioned Hangar .....	52
Figure 75: Ready Room Adjacent to Hangar Bay .....	52
Figure 76: MARS UAS Airfield Ramp Area.....	53
Figure 77: Direct Access to R6604 Restricted Airspace.....	53
Figure 78: MARS Payload Processing Facility .....	54
Figure 79: MARS Payload Processing Facility Solid Motor Processing Bay .....	54
Figure 80: MARS Payload Processing Facility Secondary Payload Processing Bay .....	55
Figure 81: MARS Payload Processing Facility Control Systems .....	55
Figure 82: UUV/USV Port Upgrade Summary .....	55
Figure 83: Integration and Control Facility (ICF) .....	56

## LIST OF TABLES

Table 1: Building E-109 Engineering Facilities .....	8
Table 2: Building F-7 Integration and Test Facilities .....	8
Table 3: Building F-10 Test and Evaluation Facilities .....	9
Table 4: EMI/EMC Facility Specifications .....	12
Table 5: Anechoic Chamber Facility Specifications.....	13
Table 6: Radar Lab Specifications .....	15
Table 7: Microwave Lab Specifications .....	16
Table 8: F-7 T-Vac Chamber Specifications .....	19
Table 9: Espec Thermal Chamber Specifications .....	20
Table 10: Building F-10 Thermal Chamber Summary .....	22
Table 11: CSBF Chamber Dimensions .....	23
Table 12: CSBF Connector Specifications .....	23
Table 13: Environmental Test Chamber Specifications.....	24
Table 14: F-10 Shaker Specifications .....	25
Table 15: E-109 Vibration Test Facilities.....	26
Table 16: Balancing Machine Specifications.....	27
Table 17: Mass Properties Measurement System .....	27
Table 18. Bend Test Fixture Specifications .....	30
Table 19: Magnetic Calibration Facility Specifications.....	32
Table 20: Solar Simulator Specifications.....	34
Table 21: F-7 High Bay East Specifications .....	39
Table 22: F-7 High Bay West Specifications.....	40
Table 23: 3D Printer Capabilities.....	44
Table 24: Assembly and Payload Processing Facilities Wallops Island.....	46
Table 25: Building D-1 Specifications.....	48
Table 26: Building N-159 Specifications.....	49
Table 27: UAS Airfield.....	51
Table 28: UAS Hangar Bay Specs.....	52
Table 29: Ready Room Specs .....	52
Table 30: Ramp Area Specs.....	53

# 1 INTRODUCTION

---

The NASA Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF), which will be referred to as ‘Wallops’ in this document, claims a heritage of low-cost operations, experienced personnel, customer-focused support, and a common-sense safety program. As an operational research site for the next generation of low-cost launch technologies, Wallops supports the commercial development of space technologies and the dissemination of information through educational and outreach programs. Wallops is recognized as a role model for pioneering productive and innovative government, industry, and academic partnerships. Our ongoing programs and projects support all NASA centers, science, and technology focuses. Wallops’ key mission elements include:

**Suborbital Flight Projects**—Wallops manages and implements NASA's sounding rocket, balloon, and scientific aircraft programs in support of Earth and space sciences. New technologies, such as ultra-long duration balloons, are integrated into the program.

**Low-Cost Orbital Missions**—Wallops manages and provides technical support for small spacecraft carriers.

**Mission Operations**—Wallops provides fixed and mobile launch ranges and a research airport. The range provides the services necessary for a wide variety of research, development, and operational missions, including rocket, balloon, and aerial vehicle flights. Wallops also manages and operates satellite tracking stations locally. The Research Range supports NASA, the Department of Defense (DoD), commercial, and academic organizations.

**Science and Technology**—Wallops Earth scientists research global climate change. Wallops engineers develop new technologies that improve capabilities of flight projects or lower costs of access to space.

**Educational Outreach**—Partnerships formed with industry and academia foster educational outreach programs. Wallops also carries out a wide array of education and outreach programs that support the development of future engineers and scientists.

## 1.1 Purpose

The Wallops Integration and Testing Handbook is a guide for planning operations at Wallops testing facilities. It provides a summary of the capabilities and technical specifications of available facilities. This handbook prescribes the information to be provided by the user that will enable the integration and testing team to effectively plan for and support the facility user’s project. Note that each facility plans for availability based on current workloads/ mission schedules. For example, sounding rockets may have between 20 and 35 missions in work at one time. Contact [scott.h.schaire@nasa.gov](mailto:scott.h.schaire@nasa.gov) for additional information.

### 1.1.1 Building E-109: Engineering

Table 1 lists the engineering facilities in Building E-109.

***Table 1: Building E-109 Engineering Facilities***

Facility	Refer to section
GPS Simulation Lab	2.3
Radar Lab	2.4
Environmental Test Chamber	3.4
Microwave Lab	2.5
Electrical Lab	2.6
Vibration Tests	0
Solar Simulator	4.4
Mission Planning Lab	5.2
Interconnect Lab (harness fabrication)	5.3
Prototype Lab (component testing)	5.4
Software Development	5.7
High Bays	4.9
Machine Shop	5.6

### 1.1.2 Building F-7: Integration and Test

Table 2 lists the integration and test (I&T) facilities in Building F-7.

***Table 2: Building F-7 Integration and Test Facilities***

Facility	Refer to section
EMI/EMC Facility	2.1
Anechoic Chamber Facility	2.2
Thermal Chambers	3.1
SmallSat MPPF	4.7
Rideshare Mission Integration Services	4.8
High Bay East and Cleanroom	4.10
High Bay West	4.11
Balloon Research & Development Lab	4.12
Machine Shop	4.7, 4.8

### 1.1.3 Building F-10: Test and Evaluation

Table 3 lists the test and evaluation facilities in Building F-10.

*Table 3: Building F-10 Test and Evaluation Facilities*

Facility	Refer to section
Telemetry Ground Stations	2.7
Thermal Chambers	3.2
Vibration Tests	3.5
Balancing Machines	3.7
Mass Properties Measurement	0
Spin Deployment	3.9
Bend Test Facility	3.10
Payload Fabrication	4.1
Attitude Control Testing Facility	4.2
Sounding Rocket Payload Integration	4.3
Machine Shop	4.1

## 1.2 Facility History

For more than 60 years, Wallops has provided launch support for some of the highest priority research programs in the United States. Founded in 1945, Wallops was established by the National Advisory Council on Aeronautics (NACA) as a test site for aeronautics research projects. During the 1940s and 1950s, prior to the era of high-speed wind tunnels, Wallops activities focused on providing operational testing for new aerodynamic configurations aboard rockets. During the 1960s, Wallops focused on support for numerous flight projects leading to human exploration of space, such as Little Joe, which tested the ejection system for the Mercury capsule. From the 1960s through the 1980s, Wallops supported the launch of more than 40 Scout rockets. During the 1990s, Wallops evolved its mission beyond operational support to include project management and implementation of various NASA space and Earth science activities aboard suborbital and small orbital carriers. During its history, Wallops has conducted more than 16,000 launches. For a more detailed history of Wallops, visit <https://www.nasa.gov/centers/wallops/home>.

## 1.3 Wallops Main Base Overview

Wallops and Research Range encompass more than 6,000 acres over three different land parcels. The Wallops Main Base is located on Virginia's Eastern Shore, 5 miles south of the Maryland state line.

The Main Base (see Figure 1) is home to most of NASA's administrative, engineering, fabrication, testing, and project management activities, as well as the Research Airport and Range Control Center. The mainland and Wallops Island are located approximately 7 miles to the southeast, adjacent to the Atlantic Ocean. Wallops Island is the site of the Wallops Launch Range (see Figure 2) and many supporting facilities. The locations of the I&T building are shown in Figure 3.



*Figure 1: Main Base and Airfield*



*Figure 2: Launch Range*



*Figure 3: Main Base and I&T Building Locations*

## 1.4 Overview of Wallops Island

Wallops Range has facilities for the receipt, inspection, assembly, checkout, and storage of rocket motors and other pyrotechnic devices. The Wallops Island launch site is comprised of launch pads, control rooms, blockhouses for launch control, and assembly buildings to support the preparation and launching of suborbital and orbital launch systems. Figure 4 depicts an aerial map of Wallops Island, showing the location of support facilities and launch pads.



*Figure 4: Wallops Island*

## **2 ELECTRICAL INTEGRATION AND TESTING**

### **2.1 EMI/EMC Measurement Facility (Building F-7)**

The electromagnetic interference / electromagnetic compatibility (EMI/EMC) Measurement Facility (Figure 5) is MIL-STD 461/462-compliant and American National Standards Institute (ANSI) C63 pre-compliant for radiated emissions (RE102), radiated susceptibility (RS103), and conducted emissions (CE102). The test chamber is lined with absorber rated to 40 GHz with 100 dB shielding. The test chamber provides a low noise environment and may be used for payload self-compatibility testing and radio frequency (RF) sensitive device characterization. Two adjoining chambers house the control room and the payload support room. Electrical pass-throughs allow for connection to customer-provided ground support equipment (GSE) in the payload support room. See Table 4 for a summary.



**Figure 5: EMI/EMC Measurement Facility**

**Table 4: EMI/EMC Facility Specifications**

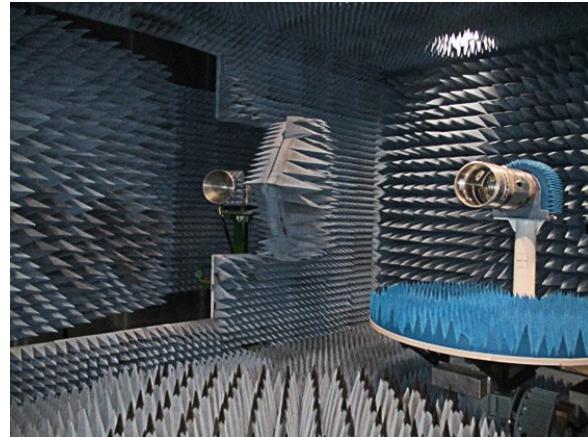
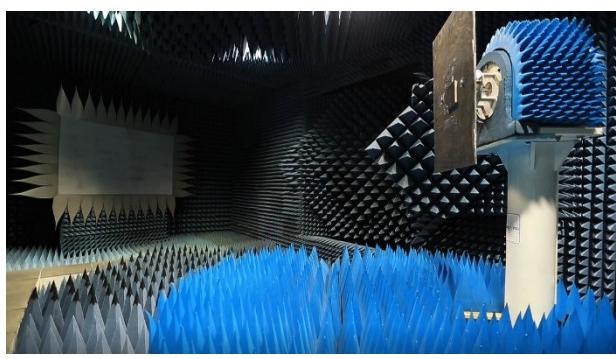
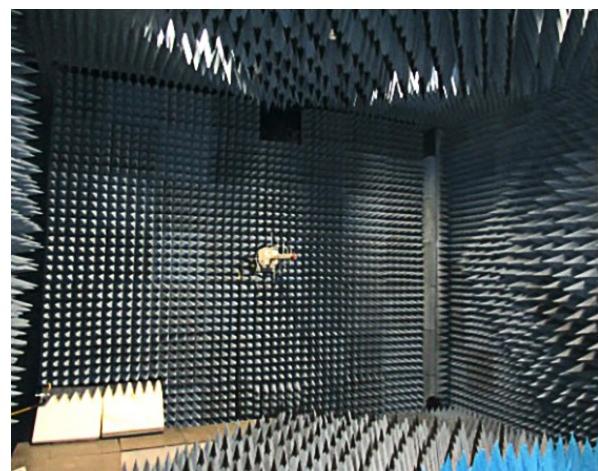
<b>Location</b>	Building F-7
<b>Measurements</b>	12 feet wide by 18 feet long
<b>Door Access</b>	7 feet high by 4 to 5 feet wide
<b>Shielding</b>	100 dB to 40 GHz
<b>Test Standards</b>	RE102, RS103, CE102

### **2.2 Anechoic Chamber Facility (Building F-7)**

The Anechoic Chamber facility (Figure 6 through Figure 9) is home to a shielded dual-mode far field/compact range chamber for measurement and analysis of linear and circular polarization antenna pattern. Its specifications are shown in Table 5. The Agilent PNA Orbit/FR spectrum-based automated data collection system allows both phase and amplitude pattern measurements with configurable settings for azimuth/roll range and step sizes with source feeds in co-polarization or cross-polarization. The Anechoic Chamber maintains feeds and standard gain horns for the following bands: UHF, L, S, C, X, Ku, and Ka.

*Table 5: Anechoic Chamber Facility Specifications*

<b>Location</b>	Building F-7
<b>Far-Field mode</b>	400 MHz to 2 GHz
<b>Compact Range Mode</b>	2 GHz to 100+ GHz
<b>90 dB Shielding</b>	to 40 GHz
<b>Elliptic Cylinder Quiet Zone</b>	6 feet wide by 6 feet deep by 4 feet high
<b>Isolation Mounted Az/El Positioner and Roll Axis</b>	Provides angular accuracy of +/- 0.005 degrees

*Figure 6: Anechoic Chamber Facility Az/El Positioner Tower**Figure 7: Anechoic Chamber Facility Compact Range Source Feed**Figure 8: Anechoic Chamber Facility Compact Range Reflector**Figure 9: Anechoic Chamber Facility Far Field Source Feed*

## 2.3 GPS Simulation Lab Facility (Building E-109)

The Global Positioning System (GPS) Simulator Facility, shown in Figure 10, is located in Building E-109 and is comprised of a 4-output Spirent GPS simulator capable of reproducing the RF signal that would be received by a GPS receiver as it travels any trajectory at any time, with parameters such as signal strength, multipathing, antenna patterns controllable for testing of navigation and attitude receivers, a single output Spirent GSS GPS receiver programmable and transportable for use in the field, and a Navigation Laboratories Tapestry GPS/Inertial Measurement Unit (IMU) simulator.



*Figure 10: GPS Simulator Lab*

## 2.4 Radar Lab Facility (Building E-109)

The Radar Laboratory Facility contains the transponder and Flight Termination Receiver System (FTS) certification benches (see Figure 11). Table 6 lists the facility specifications. The Test Equity Model 115 Thermal Cycle Chamber is shown in Figure 12. The transponder rack and parts of the FTS bench are mobile so they can be moved for remote transponder and FTS testing. For example, these are used to perform in-vehicle testing and end-to-end (ETE) testing with the Antares vehicle at the Horizontal Integration Facility (HIF).

The portable thermal cycle chamber allows for component characterization over a wide temperature range.

Ample bench space is available for component test and measurement.



*Figure 11: Flight Termination Receiver System Certification Bench*



*Figure 12: Test Equity Model 115  
Thermal Cycle Chamber*

*Table 6: Radar Lab Specifications*

Location: Building E-109
Radar Transponder Certification Bench
FTS Certification Bench
Test Equity Model 115 Thermal Cycle Chamber
Temperature Range: -73°C to +175°C
Control: +/- 0.2°C
Interior Dimensions: 16 inches wide x 12 inches high x 14 inches deep (1.55 cubic feet)

## 2.5 Microwave Lab Facility (Building E-109)

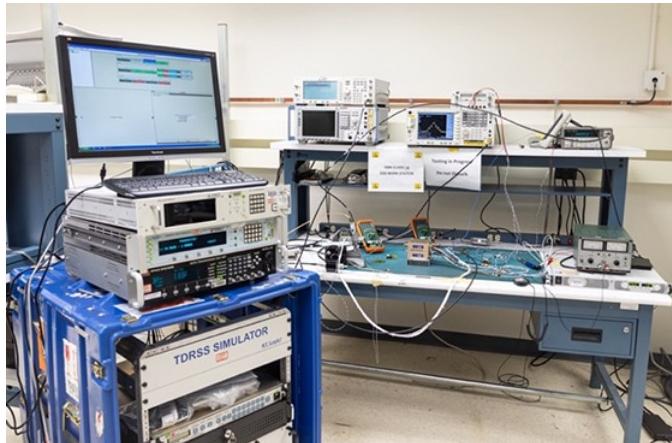
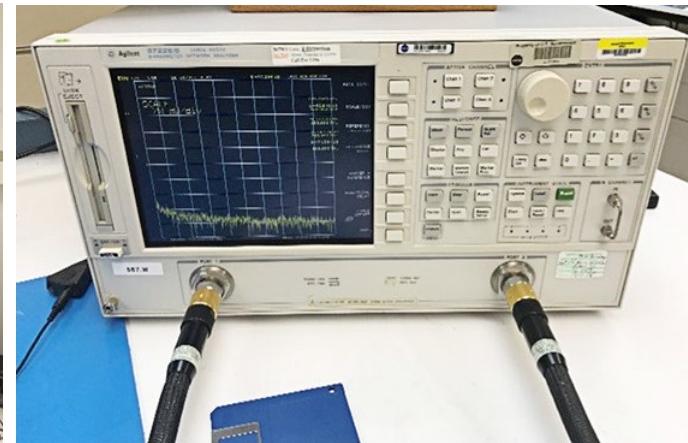
The Code 569 Microwave Lab, shown in Figure 13 and Figure 14, provides instrumentation (Figure 15) and development tools for telemetry system RF communications hardware. The lab supports testing of flight and ground support hardware, as shown in Table 7.



*Figure 13: Microwave Lab Facility*

***Table 7: Microwave Lab Specifications***

Location: Building E-109
RF test and measurement capability to 30 GHz
BPSK, QPSK, 8PSK modulation and demodulation to 480 Mbps
ESD Test and Assembly Benches
Keysight Advanced Design System (ADS) software
Field Programmable Gate Array (FPGA) development software

***Figure 14: Microwave Lab Facility******Figure 15: Agilent 8722ES Network Analyzer***

## 2.6 Electrical Lab (Building E-109)

The Wallops Code 569 Electrical Engineering Branch Electrical Lab (Room 272) supports multiple engineering and integration and testing efforts for components and small payloads. The lab, shown in Figure 16, can support class 1A to class zero missions for electrostatic discharge. A portable thermal chamber, portable laminar flow hood, and portable vacuum jar allow for environmental test capability and contamination control protections when required.

***Figure 16: Electrical Lab (Building E-109)***

## 2.7 Telemetry Ground Stations (Building F-10)

The NASA Sounding Rocket Operations Contract (NSROC) has a total of three primary ground stations with the ability to support an auxiliary testing location. Each ground station is designed to support up to eight RF links in various combinations. The typical combination is two payloads with three RF links each. The ground station can support lower S-band frequencies (2200 to 2300 MHz) and some upper S-band frequencies. Typically, most payloads are contained to lower S-band. The ground stations are in the process of being upgraded to support the C-band RF spectrum (4400 to 4850 MHz).

The ground stations, located in Building F-10, are configured to support multiple pulse-code modulation (PCM) links (defined by Inter-Range Instrumentation Group (IRIG) 106 Chapter 4). They can generate multiple outputs that can range from clock and data outputs to the raw demodulated signal if the customer decides to handle the data themselves. The ground stations can support both PCM and SOQPSK modulation with a maximum bit rate of 40 Mbps. They are also capable of demodulating TV/FM and baseband links.

The ground stations are also capable of outputting experimenter asynchronous data embedded within the telemetry downlink. This must be the RS-232 / RS-422 asynchronous protocol and our current maximum baud rate is 230.4 Kbaud. Each ground station has a dedicated IRIG CH10 recorder that can record multiple sources both inside and outside of the ground station. Every ground station is also capable of supporting paper chart recorders with a maximum of 16 channels per chart. All ground stations can simulate a command uplink for payloads that wish to have remote control during flight. This is used in combination of an on-board payload system that allows the user to control relays and uplink asynchronous data. Figure 17 shows a typical ground station setup.



*Figure 17: Telemetry Ground Station*

### **3 MECHANICAL INTEGRATION & TESTING**

#### **3.1 Thermal Chambers (Building F-7)**

##### **3.1.1 Thermal Vacuum Chamber (Building F-7)**

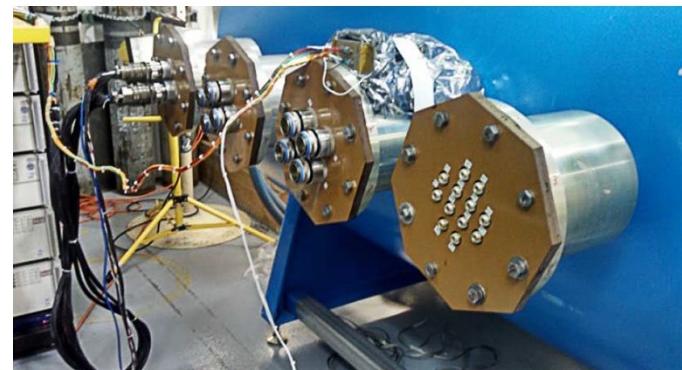
The Code 548 thermal vacuum (T-Vac) chamber in Building F-7 (Figure 18, Figure 19 and Figure 20) is cylindrical. The chamber shroud is broken up into twelve panels (ten circumferential, one on the door, and one at the rear of the chamber), all controlled independently of one another. The shroud panels utilize liquid nitrogen and block heaters for temperature control, and can maintain temperatures between  $-100^{\circ}\text{C}$  and  $+100^{\circ}\text{C}$ . A portable 10K (ISO 7) clean tent (12 feet by 16 feet) adjoining the chamber for test article processing can be utilized based on customer need.

The vacuum system consists of a two-stage pumping system. For higher-pressure tests (0.1 torr to 760 torr) such as those for balloon and aircraft tests and for initial rough pump of the cryogenic pump, the chamber utilizes an oil-free mechanical pump. For very low-pressure tests, such as those used for space flight qualification ( $<1\times10^{-5}$  torr), the second stage of the vacuum system consists of a cryogenic pump.

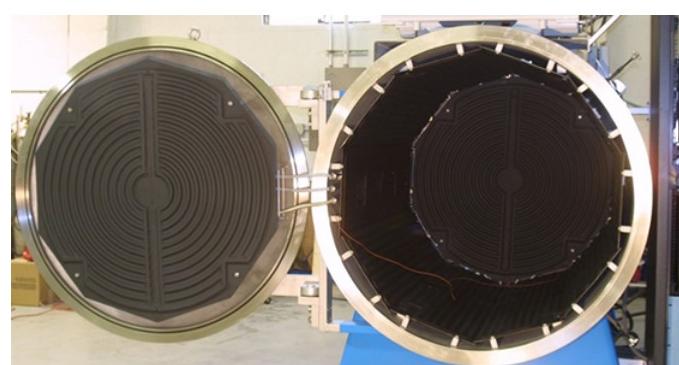
All chamber systems (vacuum and temperature) are controlled via a personal computer (PC) with LabView and a National Instruments data acquisition system and digital input/output (I/O) card.



*Figure 18: Thermal Vacuum Chamber*

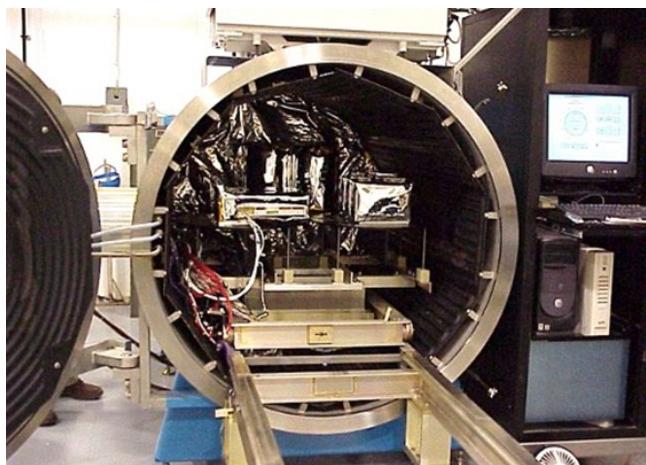


*Figure 19. Thermal Vacuum Chamber Ports*

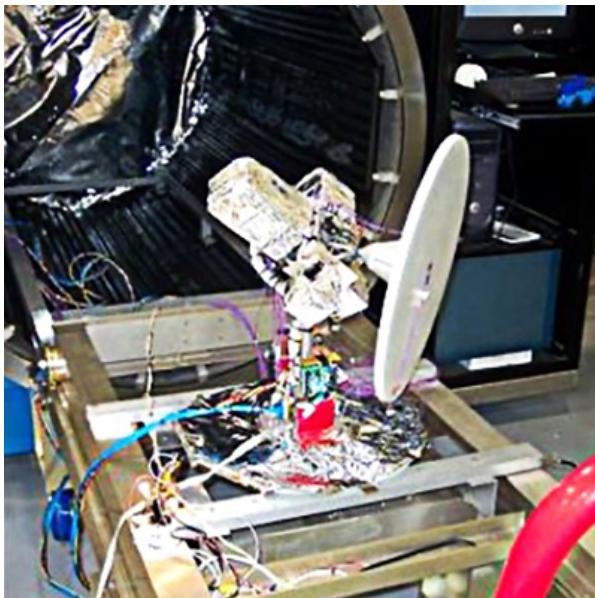


*Figure 20: Thermal Vacuum Chamber*

Temperature measurement of test articles and associated GSE are accomplished via a Fluke 2686A data acquisition unit with Precision Analog Input (PAI) modules. The unit can read up to 120 thermo-couples (or other two-wire analog inputs). Additionally, chamber GSE includes type-T thermocouples, suitable for use in vacuum environments. These plates accommodate a variety of hermetic connectors in different configurations that accommodate power, signal, and RF interfaces. Plates with



**Figure 21: Thermal Vacuum Chamber used for small spacecraft, subsystems, and components**



**Figure 22. Thermal Vacuum Chamber used for testing Balloon High Gain Antenna (HGA)**

Figure 22 shows an example of using the chamber to test a component or subsystem of a much larger mission, in this case a critical subsystem for large scientific balloon missions. Smaller projects, such as Small Satellites (SmallSats), can be accommodated completely inside the chamber for testing.

Specifications for the F-7 T-Vac chamber are shown in Table 8.

plumbing feedthroughs are available for external chillers, or custom feedthrough plates can be developed.

Mechanical GSE includes large and small open-framed carts for mounting of test articles. These carts slide on rails inside the chamber (Figure 21) and provide ample view to the bottom shroud panels. Additionally, four heater plates and two heater-controlled enclosures are available for component and subsystem testing, utilizing a cold chamber as their heat sink.

**Table 8: F-7 T-Vac Chamber Specifications**

<b>Location</b>	Building F-7
<b>Manufacturer</b>	DVI
<b>Usable Envelope / Test Volume</b>	72 inches long by 48 inches diameter
<b>Temperature Control</b>	Liquid Nitrogen and Block Heaters
<b>Temperature Range</b>	-100°C to +100°C (-148°F to +257°F)
<b>Vacuum System</b>	Two-stage Pumping System
<b>Oil-free Mechanical Pump</b>	High-pressure tests (0.1 torr to 760 torr)
<b>Operating Pressure (psi)</b>	<1x10 <sup>-5</sup> torr
<b>6 Feed-through ports</b>	Accommodate: 7.5-inch feed-through connector plates 11-inch feed-through connector plates
<b>Unique Capabilities</b>	Mechanical Pump, Cryopump, Coldfinger (C/F), Scavenger Plate (SP), Thermoelectric Quartz Crystal Microbalance (TQCM) to monitor outgassing, Residual Gas Analyzer (RGA) for process control and contamination monitoring, 10K Clean Tent

### 3.1.2 Thermal Chamber (Building F-7)



*Figure 23: Thermal Chamber (Building F-7)*

The Code 569 thermal chamber in Building F-7, shown in Figure 23, provides 32 cubic feet of test volume with touch screen control, programmable thermal test profiles, data logging capability, and ethernet connectivity. A dry air purge is provided to eliminate condensation buildup on test components. The chamber offers a temperature range of -70°C to +180°C with +/- 0.5°C control ability (see Table 9). This chamber is located within close proximity to the F-7 EMI and Anechoic chambers allowing for thermal conditioning of components or antennas prior to testing in those chambers.

*Table 9: Espec Thermal Chamber Specifications*

<b>Model</b>	Espec Platinous EPZ-4H
<b>Temp Range</b>	-70°C to +180°C
<b>Temp Control</b>	+/- 0.5°C
<b>Volume</b>	32 cubic ft (39.4" x 35.5" x 39.4")
<b>Purge</b>	Dry air available

## 3.2 Thermal Chambers (Building F-10)

### 3.2.1 Thermal Vacuum Chamber (Building F-10)

The thermal vacuum chamber in Building F-10 (see Figure 24) has an Agilent turbopump vacuum system with an oil-free roughing pump. It includes a thermal plate for hard attachment of the test item to ensure the best thermal transfer, five available thermocouples, two 37-conductor interfaces (one twisted pair, one not), with 37 pin cannons inside and out, and multi RF connectors. Typical testing is done in two days per cycle; day one hot, day two cold, with the chamber left in vacuum overnight. Data logging captures the temperature of the test article and the vacuum level.



*Figure 24. Thermal Vacuum Chamber (Building F-10)*

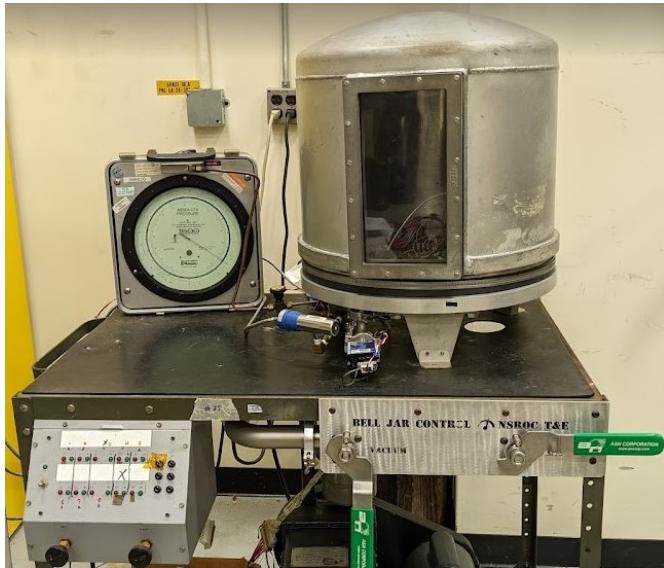
### 3.2.2 PV/T Vacuum Chamber (Building F-10)

The PV/T or “White Elephant” shown in Figure 25 is the largest chamber at 7 feet in diameter and 12 feet long. It is primarily used for performing corona checks on subsystems that utilize high voltage components.



*Figure 25: PV/T Vacuum Chamber*

### 3.2.3 Altitude Bell Jar (Building F-10)



The bell jar is shown in Figure 26 and is used primarily for automated altitude switch testing; however, it can be interfaced for small component corona tests as well.

*Figure 26: Altitude Bell Jar*

### 3.2.4 Espec ESZ-4CA Thermal Chamber (Building F-10)

There are two full-time Espec thermal chambers, one of which is shown in Figure 27. They are fully automated and have Product Temperature Control, Air Temperature Control, and Soak Control functions. One of the chambers has liquid nitrogen cooling capability allowing for cooling rates as fast as 5°C per minute. Table 10 summarizes technical data on all these chambers.



*Figure 27: Espec ESZ-4CA Thermal Chamber*

*Table 10: Building F-10 Thermal Chamber Summary*

Manufacturer	PV/T Inc.	Tenney Space Simulation System	Altitude Bell Jar	Vacuum Test Stand	Espec ESA-4CA (Qty. 2)
<b>Inside Dimensions</b>	7 feet diameter x 12 feet long	2 feet diameter x 2 feet long	1.5 feet diameter x 1.5 feet long	Up to 22 inches diameter	3 feet diameter x 3 feet long
<b>Minimum Pressure</b>	$8 \times 10^{-2}$ torr	$5 \times 10^{-6}$ torr	$1.4 \times 10^{-1}$ torr	$1 \times 10^{-6}$ torr	N/A
<b>Temperature Range</b>	Heat lamps used if needed	-75°C to +100°C	N/A	N/A	-70°C to +150°C
<b>Pump Type</b>	Mechanical	Turbo	Mechanical	Turbo	N/A
<b>Clean Environment?</b>	No	Yes	No	No	Yes

### 3.3 CSBF Thermal Vacuum Facility

The Columbia Scientific Balloon Facility (CSBF) thermal vacuum facility has a temperature range of -80°C to +70°C (temperature regulation only at ambient pressures) and pressure range of Ambient to 3 mb (coarse pressure regulation only). Figure 28 shows the interior of the chamber. Chamber dimensions are shown in Table 11. Connector specifications are described in Table 12.

**Table 11: CSBF Chamber Dimensions**

<b>Interior Dimensions</b>	
Opening Width	6 feet
Opening Height	6 feet
Depth in Chamber	8 feet
<b>Useable Test Article Dimensions</b>	
Width	66 inches
Height	69 inches
Length	78 inches

**Figure 28: CSBF Thermal Vacuum Chamber****Table 12: CSBF Connector Specifications**

<b>Quantity</b>	<b>Type or Purpose</b>	<b>External Connector</b>	<b>Internal Connector</b>
4	Cat5e Network	RJ45 plug	RJ45 plug
12	RF	BNC female	BNC female
30	16 AWG	screw terminal	screw terminal
21	14 AWG	screw terminal	screw terminal
4	10 AWG	5/16" ring terminal	1/4" ring terminal
2	PS2 keyboard/mouse	6-pin mini-DIN female	6-pin mini-DIN male
2	VGA video	DE-15 female	DE-15 male
2	3-wire serial (pins 2_3_5)	DB-9 female	DB-9 female
1	9-wire serial	DB-9 male	DB-9 female
2	3-wire serial (pins 2_3_5)	DB-9 male	DB-9 female
1	3-wire serial (pins 2_3_5)	DB-9 female	DB-9 male
2	dual outlet, 120V AC dimmable	dimmer switch	NEMA 5-15 (3 prong outlet)

### 3.4 Environmental Test Chamber (Building E-109)

The Environmental Test Chamber (Model T5ST) from Lunaire LTD Tenney Environment Inc., shown in Figure 29, is a small temperature-controlled chamber used for thermal conditioning of small components. The portable chamber loads through a front opening door that has a viewing window. The instrumented payload is installed in the chamber with no special handling or mounting fixtures and is connected to the ground support equipment via a port.

Typically, temperature is set prior to setting pressure. The payload is heated or cooled to the desired temperature with air in the chamber and remains for an hour or more. Then the pressure is set, and the temperature may change toward ambient.

The chamber uses room air. There is a manual system to add dry air to the chamber once closed to minimize the humidity in the chamber. If this is not done, frost almost certainly will appear inside the chamber at below freezing temperatures. Even with the dry air purge it is possible for a small amount of frost to form.

The chamber has a 55-pin pass-through connector for users to make harnesses for inside and outside the chamber. The connectors are such that the internal and external connectors can be mated for bench testing. There is also a terminal strip with approximately 25 lines for quick and simple pass-through. There is a pass-through connector consisting of Ethernet CAT 6, FireWire, and USB-C cables, with lengths of about 4 feet inside the chamber and about 6 feet outside the chamber. All connections except the terminal strip are mounted on International Standards Organization (ISO) NW100 LF plates; users can make custom pass-throughs using their own ISO NW100 LF plates. Table 13 lists the chamber specifications.



**Figure 29: Environmental Test Chamber Model T5ST**

**Table 13: Environmental Test Chamber Specifications**

<b>Location</b>	Building E-109
<b>Manufacturer</b>	Tenney
<b>Pressure</b>	0.1 Torr
<b>Temperature</b>	-70°C to +170°C (-94°F to 338°F)
<b>Dimensions</b>	21 inches deep by 24 inches high by 21 inches wide
<b>Unique Capabilities</b>	Optical Window

### 3.5 Vibration Test Facilities (Building F-10)

There are four shakers used for component and payload vibration tests at Wallops with the technical information shown in Table 14. Figure 30 shows a typical test setup. Figure 31 shows the Unholtz Dickie (UD) Small Chamber.



*Figure 30: Vibration Table*



*Figure 31: UD Small Chamber*

*Table 14: F-10 Shaker Specifications*

<b>Ling Electronics Shaker B340:</b>	
Rated Force Sine	30,000 lb.
Rated Force Random	30,000 lb. rms
Frequency Range	5 to 2000 Hz
Maximum Displacement Peak-Peak	1 inch
<b>NOTE:</b> The B340 can be rotated to mate with a Team Corporation model 482 sliding table so that it can be used for both thrust axis and lateral vibration tests. Maximum pitch moment capacity = 1,200,000 lb.-in.	
<b>Ling Electronics Shaker B335 (2):</b>	
Rated Force Sine	18,000 lb.
Rated Force Random	18,000 lb. rms
Frequency Range	5 to 3000 Hz
Maximum Displacement Peak-Peak	Thrust: 2 inches Lateral:1 inch
<b>NOTE:</b> The B335 can be rotated to mate with a Team Corporation model 1830 sliding table so that it can be used for both thrust axis and lateral vibration tests. Maximum pitch moment capacity = 300,000 lb.-in.	
<b>UD Shaker S452:</b>	
Rated Force Sine	6000 lb.
Rated Force Random	5,500 lb. rms
Frequency Range	5 to 3000 Hz
Maximum Displacement Peak-Peak	2 inches

**NOTE:** The Wallops Shaker test facilities have 11-inch cube fixtures available for testing small components in all three axes by mounting the test article in different orientations. In addition, Wallops can support design and fabrication of custom vibration fixtures to interface between the test article and shaker head.

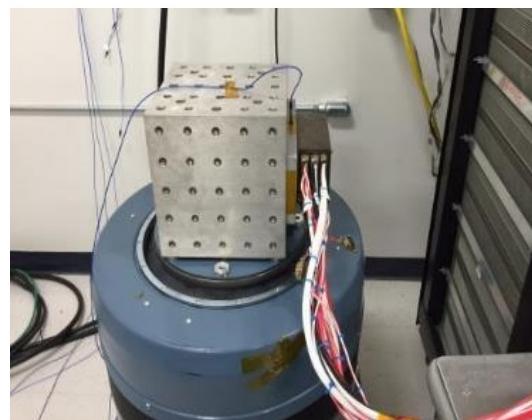
At the engineer or principal investigator's request, sensors can be mounted to components or areas of interest. Wallops Shaker test facilities have 16-channel capability; through this in-test data and the vibration control software, test profiles can be force limited to prevent damage to the test article. Specific test profiles, including reduced inputs at given frequencies (notching), can be created using the vibration control software as well.

### 3.6 Vibration Test Facilities (Building E-109)

There are additional vibration test facilities in Building E-109, as described in Table 15 and shown in Figure 32.

*Table 15: E-109 Vibration Test Facilities*

<b>Location</b>	Building E-109
<b>Fixture</b>	10 inches by 10 inches high-strength magnesium alloy mounting fixture
<b>Shaker</b>	
<b>Sine &amp; Random rating</b>	2200 lbs.
<b>Maximum Shock</b>	4500lbs.
<b>Frequency Range:</b>	5 Hz to 2 kHz
<b>Accelerometers:</b>	Various sizes, single axis, tri-axis
<b>Software</b>	Unholtz-Dickie Corporation
<b>Performance Applications</b>	Sine/Random/Shock Space qualification testing Environmental testing for electronic flight hardware



*Figure 32: Vibration Test*

### 3.7 Balancing Machines (Static and Dynamic) (Building F-10)

At Wallops, a Gisholt Rocket Balancing Machine, shown in Figure 33, is used to balance sounding rocket payloads.

This machine's specifications are listed in Table 16:

*Table 16: Balancing Machine Specifications*

<b>Location</b>	Building F-10
<b>Maximum payload weight</b>	1500 lbs.
<b>Maximum height of CG above table</b>	10 feet
<b>Measurement accuracy</b>	2.0 oz-in <sup>2</sup> at 225 RPM or more



*Figure 33: Balancing Machine*

### 3.8 Mass Properties Measurement System (Building F-10)

The Environmental Testing and Evaluation Group at Wallops is equipped with an Airdyne Mark 8 mass properties measurement system shown in Figure 34 through 37. This unit is used for measuring center of gravity (CG) locations and moments of inertia (MOI) on sounding rocket subsystems and payload stacks. Important technical data is shown in Table 17:

*Table 17: Mass Properties Measurement System*

<b>Location</b>	Building F-10
<b>Maximum test article weight</b>	5,000 pounds
<b>Maximum CG height above the table</b>	120 inches
<b>CG and MOI measurement accuracy</b>	0.1%



*Figure 34: Mass Properties Measurement System*



*Figure 35: Mass Properties Measurement System*



*Figure 36: Mass Properties Measurement System*



*Figure 37: Mass Properties Measurement System*

### 3.9 Spin Deployment Facility (Building F-10)

Payloads with deployable booms, nose cones, doors, etc. can be tested for proper operation using the spin deployment and separation chamber located in Building F-10, as shown in Figure 38. The rotary table can spin a payload to a rate of 20 RPS while withstanding an imbalance of up to 3000 ft-lb. 5 feet above the table surface. The chamber is equipped with a heavy-duty Kevlar® tarpaulin around the rotary table for catching deployed components. There are also video cameras mounted on the chamber walls for recording and timing the deployment events. Pyrotechnic release devices can be activated by connecting lead wires through a 20-channel slip ring that allows the table to rotate while maintaining electrical continuity.



*Figure 38: Spin Deployment Facility*

### 3.10 Bend Test Facility (Building F-10)

Every sounding rocket payload is subjected to a bend test to determine the overall stiffness of the body. This information is used by the Flight Performance Group to verify payload stability during flight. The bend test fixtures at Wallops consist of a base plate mounted to the concrete floor and a pneumatic (WFF) linear actuator mounted to a steel I-beam pillar. The pistons are equipped with load cells, which are used to measure and control the applied load. The aft end of the payload is fastened to a base plate, and the actuator's position along the pillar can be adjusted to the proper height on the payload being tested. Land surveying equipment is used to accurately measure the tip deflection of the payload as the actuator applies lateral loads in both directions. Table 18 lists the fixture specifications. Figure 39 shows a typical test setup.

*Table 18. Bend Test Fixture Specifications*

<b>Facility</b>	Building F-10
<b>Maximum Load (actuator or load cell)</b>	+/- 5,000 pounds
<b>Maximum Actuator Height</b>	21 feet
<b>Accuracy of Deflection Readings</b>	0.05 inches



*Figure 39: Bend Test Fixture*

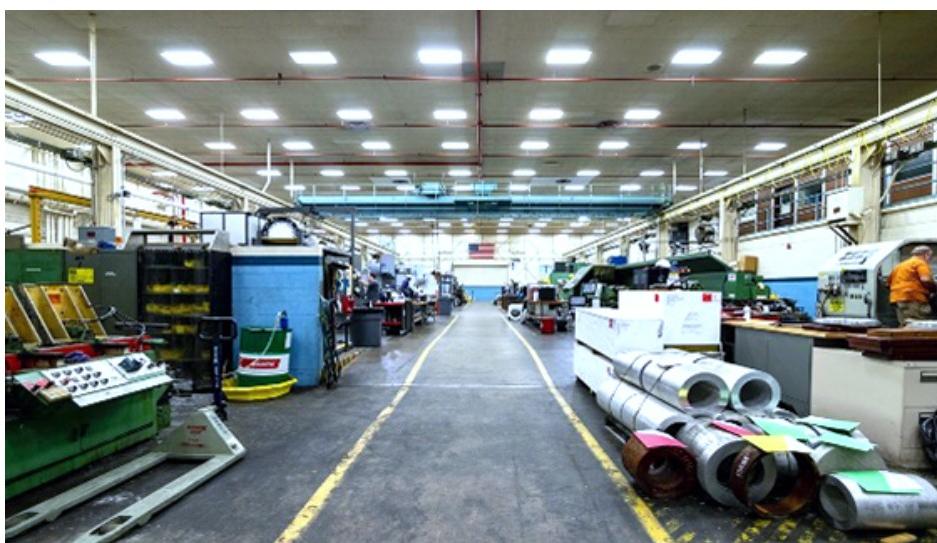
## 4 Payload Fabrication, Integration & Testing

### 4.1 Payload Fabrication (Building F-10)



*Figure 40: Fabrication Facility*

Wallopss has a fully equipped machine shop in Building F-10, as shown in Figure 40 and Figure 41, that can provide electronic, electrical, and mechanical support. The 26,000-square-foot machine shop includes a large selection of Computer Numerical Control (CNC) mills and lathes, manual machines, sheet metal fabrication, welding, and heat-treating facilities. Capabilities include full computer-aided design and manufacturing (CAD/CAM) implementation in developing and fabricating mechanical systems, optical instrumentation, and payload components for flight research. The fabrication area performs functions such as sounding rocket launcher refurbishment, design and fabrication of mobile telemetry and mobile radar support vans and antenna systems. The machine shop includes mechanical technician areas for assembly of scientific sounding rocket payloads. While the facility primarily supports the Sounding Rocket Program, it regularly supports other NASA and reimbursable projects. The facilities are managed through the NSROC.



*Figure 41: Fabrication Facility*

## 4.2 Attitude Control System Testing (Building F-10)

Wallop supports Attitude Control System (ACS) testing for subsystems such as IMUs, star trackers, magnetometers, sun sensors, reaction wheels and torque rods. High intensity light sources in a clean room may be used to examine sun sensors. A star simulator is available for star tracker functional verification. A single axis rate and magnetic torque table are available with hand crank for basic verification of reaction wheels, torque rods, and IMUs. The Magnetic Calibration Facility in Building F-10, shown in Figure 42 and Figure 43, may be used for magnetometer and torque rod testing. The Magnetic Calibration Facility is used to conduct magnetic calibration of magnetometers on sounding rocket payloads and to perform functional tests on magnetic attitude control systems. When required, magnetic calibration tests are done – generally for all payloads with magnetometers except those in which the magnetometers are used as roll or yaw indicators. The testing equipment consists of a three axis, 40-foot square Braubek system which can cancel the effects of the Earth's magnetic field and then generate a test field in any direction.



*Figure 42: Magnetic Calibration Facility*

Technical data are listed in Table 19:

*Table 19: Magnetic Calibration Facility Specifications*

<b>Physical Dimensions:</b>	
Access Opening	8 feet 8 inches high by 7 feet 5 inches wide
<b>Static Field Environment:</b>	
Magnitude (each axis)	±100K Gamma
Step Resolution	±3.7 Gamma
Stability	±10 Gamma / minute for first 30 minutes ±3 Gamma / minute after first 60 minutes
Homogeneity	0.02% 6-foot spherical diameter
<b>Dynamic Field Environment:</b>	
Magnitude	+60K Gamma
Frequency	10 Hz (although 10 Hz to 100Hz @ 1K Gamma has been performed)
<b>Turtable</b>	
4-foot diameter	
<b>Coil Orthogonality</b>	
1.8 arcminutes	
<b>Fields</b>	
Earth, 0 to 15 Volts DC, 0 to 25 Amps	
Test (3-axis), 50 Volts AC, ±8 Amps	
Gradient 15 Volts DC, 6 Amps	



*Figure 43: Magnetic Calibration and Testing*

### 4.3 Sounding Rocket Payload Integration (Building F-10)

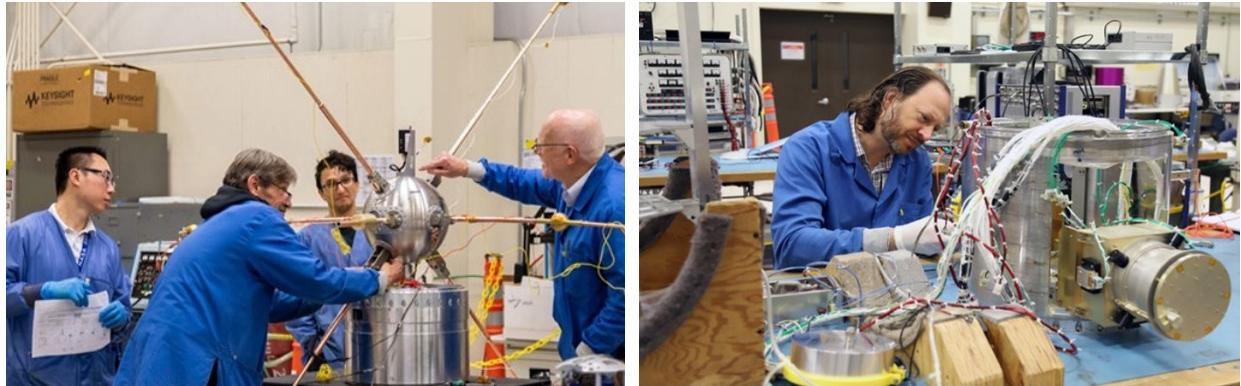
Building F-10 has three independent payload I&T areas (see Figure 44 and Figure 45 for representative facilities).

Payload integration is the first-time assembly of all the parts and pieces with experiment hardware into the launch configuration. All aspects of the design and operation are checked including mechanical fit and operation, telemetry and electrical systems operation, and systems compatibility. Pre-testing sequence tests are performed to ensure the event-programming system functions properly.

Each I&T area has its own independent telemetry ground station. The telemetry ground station can support multiple links for all systems flown.



*Figure 44: Payload Integration and Testing*



*Figure 45: Payload Integration and Testing*

#### 4.4 Solar Simulator (Building E-109)

This solar simulator is based on a Fresnel lens to collimate the light beam from the 3.0kW Xe ozone-free arc lamp source, resulting in highly collimated illumination of the target spot. The spectral distribution of the xenon light source, along with the use of specially calibrated air mass filters, closely simulates the Sun's true spectral distribution in various conditions on Earth.

This is a single star simulator, shown in Figure 46, with features described in Table 20:

*Table 20: Solar Simulator Specifications*

Location: Building E-109
Canadian optics with UV-browning plastic
Non-offensive light shiner
Sun in a box
Artificial Sun source for non-tanning applications
3 kW Fresnel Lens, Xenon Lamp Solar Simulator
11-inch beam diameter
~1350 W/m <sup>2</sup> maximum output
Two-axis gimbal and linear actuators available



*Figure 46: E-109 Solar Simulator*

## 4.5 SmallSat and Balloon Payload Integration (Building F-7)

Wallop Flight Facility Building F-7 (Figure 47 and Figure 48) houses the main base SmallSat and Balloon payload integration facilities.

Figure 49 shows supplemental integration workspace that supports work station setup for small mission I&T as well as thermal vacuum testing.



*Figure 47: Integration and Test (Building F-7)*



*Figure 48: Integration and Test (Building F-7)*



*Figure 49: Building F-7 Supplemental Integration Workspace*

## 4.6 Payload Processing Facility (PPF)

The Payload Processing Facility (PPF), H-100, is located outside Wallops Main Gate behind the Marine Science Consortium.

There are two 100,000 Class clean rooms, one high bay and one low bay with adjoining work spaces supported by redundant chillers for high reliability. The spacecraft launch control center, located adjacent to the high bay, has pass-throughs for GSE cabling and tools, as well as a display for visibility during spacecraft fueling integration and launch. The PPF has an extensive flexible support capability, as shown in Figure 50, that boasts bridge cranes, scissor and fork lifts, pressurized commodity systems for clean nitrogen, helium, and air, secure access and 24-hour video surveillance, visitor area, staging pad, and other support amenities. Office space for the payload team is available with 24 cubicles, adjacent conference room with observation windows overlooking the payload bays.



*Figure 50: Payload Processing Facility*

## 4.7 SmallSat Multi-Payload Processing Facility (Building F-7)

The Multi-Payload Processing Facility (MPPF, Building F-7) includes a minimum of two dedicated lab spaces for the purpose of small satellite assembly, integration, and test, as shown in Figure 51 and Figure 52. Lab spaces include full electrostatic discharge (ESD) workstations and clear work areas including multiple laminar flow benches, a small thermal chamber and other small-scale test equipment. One lab space includes a dedicated optical bench work area to support development and assembly, integration and test activities for optical experiments and subsystems.



*Figure 51: SmallSat Lab*

Adjacent workspaces in the MPPF available to support small satellite processing include the Wallops thermal vacuum chamber, an EMI/EMC chamber, and an Anechoic chamber for antenna pattern testing. In addition, there are temporary office workspaces, as shown in Figure 53, for visiting

project personnel including conference capabilities, and open work areas for larger assembly work and a small machine shop.



*Figure 52: SmallSat Lab*

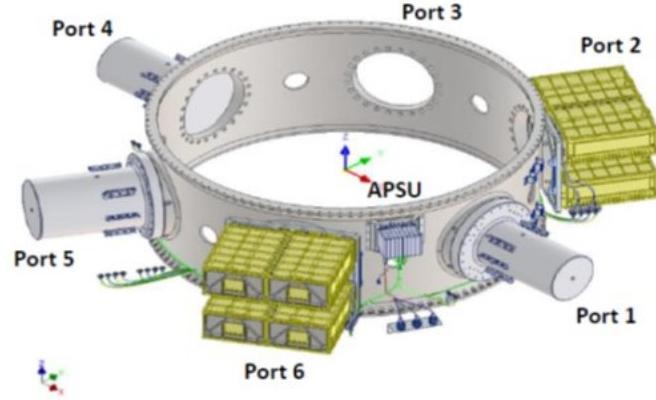


*Figure 53: Supplemental Integration Workspace*

## 4.8 Rideshare Mission Integration Services (Building F-7)

The east end of the MPPF has been configured to provide end-to-end small mission integration services, most recently demonstrated for the Landsat-9 Expendable launch vehicle Secondary Payload Adapter (ESPA) Flight System (L9EFS) project.

Custom I&T hardware, mechanical ground support equipment (MGSE), and electrical ground support equipment (EGSE), shown in Figure 54, Figure 55, and Figure 56, developed to support L9EFS are now available for future Rideshare mission support along with similar I&T hardware and capabilities for other complex special projects such as attached International Space Station (ISS) payloads and ESPA-class spacecraft. Facilities are ideal for receipt, inspection, and preparation of ESPA hardware, integration activity (payload-to-ESPA), and integrated ESPA pre-ship checkout prior to shipment to launch vehicle site.



*Figure 54: Landsat 9 Integration*

Facility capabilities to support Rideshare/ESPA and other mission I&T include a Class 100K clean room with internal Class 10K tent, an adjacent gowning area that includes equipment and cable pass-throughs, a receipt/shipping anteroom with airlock, adjacent support labs for equipment not required to be in the clean room and other supporting workspaces. The East I&T complex is also adjacent to the Wallops thermal vacuum chamber, the EMI/EMC chamber, a small machine shop, and available office space for visiting project personnel.



*Figure 55: Integrated ESPA ring prior to leaving Wallops (Building F-7)*



*Figure 56: EFS Assembly Stand*

## 4.9 High Bays (Building E-109)

Building E-109 is equipped with two integration high bays (see Figure 57) – Room 158, or East High Bay and Room 159, or West High Bay. Both rooms are approximately 885 square feet each and both have a 5-ton monorail crane with a hook height of 17 feet. Both rooms have large roll-up doors leading to the Building E-109 loading dock for equipment loading or off-loading. There is a large interior roll-up door allowing access from one high bay to the other for projects needing the extended space of both high bay rooms. Either room can be configured for ESD operations and cleanliness requirements can be met with project-provided portable flow hoods or portable clean tents.



*Figure 57: Building E-109 High Bays*



## 4.10 High Bay East (Building F-7)

Building F-7 High Bay East holds a class 100,000 cleanroom with a class 10,000- clean tent (see Figure 58 and Figure 59) with a 40-foot by 60-foot cleanroom with 20-foot by 40-foot Airlock/ Ante Room, and a 5-ton bridge crane with a 25-foot hook height and remote controls. High Bay East specifications are shown in Table 21.

**Table 21: F-7 High Bay East Specifications**

<b>Location</b>	Building F-7
<b>Cleanroom Classification</b>	Class 100,000
<b>High Bay Dimensions</b>	60 feet long by 40 feet wide by 30 feet high
<b>High Bay Area</b>	2,400 square feet
<b>Clean Work Area (CWA)</b>	Class 100K (Level 4)
<b>Airlock / Ante Room Dimensions</b>	20 feet by 40 feet
<b>Bridge Crane</b>	5-ton with 25-foot hook height
<b>Clean Tent Dimensions</b>	23.75 feet x 14.5 feet
<b>Clean Tent Classification</b>	Class 10,000



**Figure 58: High Bay East Cleanroom Tent with ESPA ring integration ground support equipment in the foreground**



**Figure 59: High Bay East Cleanroom**

## 4.11 High Bay West (Building F-7)

Building F-7 High Bay West (Figure 60) is where balloon payloads and Wallops Arc Second Pointer (WASP) systems are typically integrated. It is 1789 square feet and approximately 34 feet by 52 feet. Please see Table 22 below for specifications:

*Table 22: F-7 High Bay West Specifications*

Doors	Rollup facing north and south
Cranes	Monorail with two five-ton trollies at 30-foot hook height
Compressed Air	Clean, dry, compressed air (<150 psi)
Power	110 V
High Bay Dimensions	34 feet by 52 feet
High Bay Area	1789 square feet
Location	Building F-7
Clean Work Area (CWA)	None



*Figure 60: High Bay West*

## 4.12 Balloon Research and Development Laboratory (Building F-7)

The Balloon Research and Development Laboratory (BRDL) in Building F-7 (Figure 61) is a specialized facility equipped with customized and unique tools and equipment to support the testing, research, and technology needs for terrestrial and planetary balloons, as well as other lighter-than-air structures. Laboratory resources include static and servo-hydraulic mechanical testing machines (Figure 62) equipped with customized sensors and accessories for characterizing thin polymeric films, plastics, fibers, cords, textiles, ceramics, metals, and composites. It is equipped with non-contact strain measurement equipment for testing inflatable structures and other components or subsystems using state-of-the-art equipment and accessories. Other capabilities include pressure systems equipped with various pressure gauges for characterizing inflated structures, environmental chambers for cryogenic and non-ambient testing, and an ultraviolet exposure facility for the assessment of environmental exposure effects on materials and components. The lab has a heat-sealing machine and tools for fabricating test articles as well as capabilities for testing model balloons and other inflatable structures. Staff design, test, calibrate and validate various sensors for in-flight balloon performance and related measurements. The BRDL engineers and technicians routinely design and build customized testing tools to meet specific testing or research and development activities or needs. Various drafting and analytical tools are available for design and data analysis. The BRDL supports anomaly and technical investigations as needed and has supported various projects at Wallops and agency-wide.



*Figure 61. Balloon Research and Development Lab*



*Figure 62. Balloon Research and Development Lab Mechanical Testing Facilities*

## 5 ENGINEERING SUPPORT

### 5.1 Overview

Engineering support at Wallops includes guidance navigation and control and missions systems engineering, mechanical systems, electrical, and systems software. The Engineering team offers a broad range of skills in conjunction with Wallops' exhaustive array of I&T facilities. Wallops Engineering provides an array of useful tools to support the life cycle of mission operations including pointing systems for balloon and ISS payloads such as the Wallops Arc Second Pointer (WASP, see Figure 63) and planning tools for small satellite and suborbital payloads in the Mission Planning Lab (MPL).



*Figure 63: Wallops Arc Second Pointer (WASP)*

### 5.2 Mission Planning Lab (Building E-109)

The Mission Planning Lab guides early-stage SmallSats through a week-long study to turn a science concept into a feasible mission that gives the science team a solid foundation on which to build a competitive proposal. Since 2014, the MPL has worked with NASA SmallSat developers and their partners to provide services in systems engineering, 3D modeling, simulation, flight trajectory formulation, and more. The MPL has served mission concepts of all kinds, from formation flying proposals to deep space missions to Mars and Venus. Additionally, MPL has sub-orbital experience and works with sounding rockets, balloons, and other platforms. Over the course of one action-packed week, engineers across a range of specialties come together to meet with a mission's science team and crunch numbers. At the end of the process, scientists gain a better understanding of how to achieve their research objectives, and they come away with a valuable packet of information describing the technical details of their mission.

### 5.3 Interconnect Lab (Building E-109)

The Wallops Code 569 Electrical Engineering Branch Interconnect Lab (Room 273, see Figure 64) is responsible for fabrication, building, and testing of harnesses and circuit boards in support of multiple missions. Harness fabrication is performed by certified technicians for applications including ground support equipment, bench testing, environmental testing, flight line, and spacecraft. Harness testing may include thermal conditioning, pull tests, hi-pot tests, and automated continuity tests. Board population and repair may be performed in this lab, along with enclosure customizations with an in-lab drill press and engraving machine.



*Figure 64: Interconnect Lab (Building E-109)*

## 5.4 Prototype Lab (Building E-109)

The Mechanical Systems Engineering Branch Prototype Lab, shown in Figure 65, provides capabilities to rapidly build prototype parts to test form, fit and function. This lab has been used on many missions ranging from large spacecraft like Global Precipitation Measurement (GPM) to small electrical boxes for test components on balloon and sounding rocket missions. The Prototype Lab hosts a 3D printer which enables large build volumes and capabilities to print various types of plastics. Small parts can be printed alone or with other small parts simultaneously to fill the volume. Larger pieces can be sectioned, and individual parts can be built and assembled to prototype larger components. After all the parts are printed, they are assembled in this area either on a shop bench or on a clean horizontal work bench.



*Figure 65: Prototype Lab (Building E-109)*

## 5.5 3-D Printer (Building E-109)

The E-109 Stratasys F370 3-D Printer, shown in Figure 66, is operated by Code 548 and located in E-109. Capabilities include the use of three different build materials and their respective properties to meet the needs of the user. The F370 can provide different layer thicknesses, as the part is fabricated. The layer thickness ranges from .005" to .013" (layer thickness varies with material). Parts can be fabricated within a tolerance range of +/- .002". The printer uses Grab CAD software to upload and select setting to ensure proper build properties and orientation for printing to capture key features of the part.

The printer system consists of two extrusion heads, one for model material, and another for support material. The printer features four primary/backup material bays for build and support materials, which allow for an autonomous and continuous, build of a part within the reusable envelope. The F123 series printer utilizes four different extrusion heads that can be switched out to accommodate different print material. See Table 23 for a description of printer capabilities.

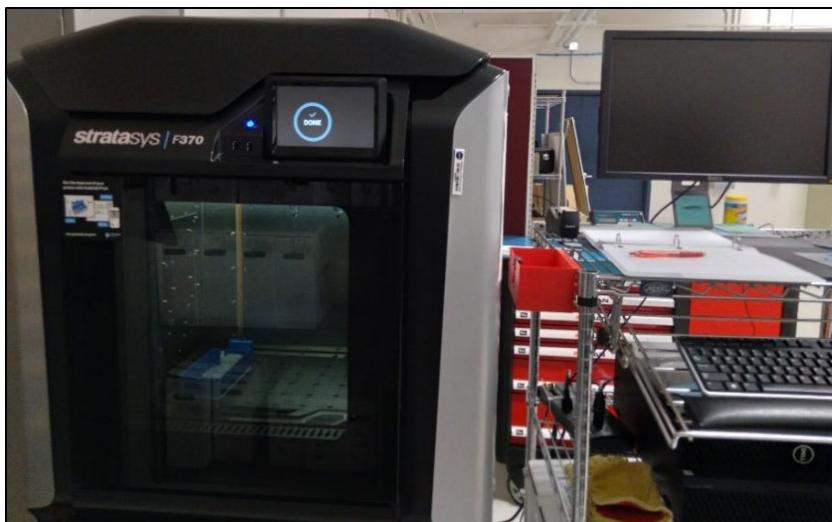
**Table 23: 3D Printer Capabilities**

<b>Product Application</b>	Prototype Parts
	Non-Critical/Structural Hardware
<b>Usable Envelope</b>	14" X 10" X 14"
<b>Material</b>	ABSM, PC-ABS, ABS ESD-7, ASA, PLA, TPU 92A, Diran Material Properties Link: <a href="https://www.stratasys.com/materials/search">https://www.stratasys.com/materials/search</a>
<b>Auto Changeover Capabilities</b>	Switches material if bay becomes empty

Note: The E109 vibration table (see section 0) is located in the Prototype Lab.

## 5.6 Machine Shop (Building E-109)

The mechanical fabrication shop is outfitted with various types of machining equipment to support manufacturing of test parts and rapid modification of flight hardware if needed. Hand tools and benches allow modest changes that need quick turnaround, like tapping threads or enlarging holes on mating parts. Standard manual tooling machines allow technicians to create or modify components with general tolerances. The lab is also equipped with a CNC mini-mill for higher precision parts that require tight tolerances.



**Figure 66: E-109 3-D Printer**

## 5.7 Software Development (Building E-109)

Wallopss develops flight and ground data systems for sub-orbital and special orbital Earth and space science missions. The software development team performs prototyping in collaboration with other NASA and Government organizations, universities, and commercial partners to advance the state of the art in implementation of its functions and related technologies.

The Code 589 Systems Software Engineering Lab (Building E109, Room 268) is a software development lab that also provides the capability to test range data systems prior to installation in an operational environment. In the lab are copies (hardware and software) of range data systems that are used to process range data during missions. The lab has access to data on the Range Mission Network, serial and ethernet Radar Data, RADAC and VTARS Mission Graphics data and slaving data, as well as Range Timing – including ASCII time, IRIG-B and pseudo IRIG-B/Countdown time. The lab has the ability to record data for future playback. The lab also has the capability to play customer provided Chapter 10 files via telemetry systems located in the lab. An example of lab use is a range customer that utilizes Code 589 personnel and the Systems Software Engineering lab to develop and test custom telemetry data display systems prior to use during their launches. The use of the Code 589 lab for development and testing provides capability independent from the range and greatly reduces the stress on the range real-time operations team which may be supporting other projects or preparing for other operational support.

## **6 OTHER SUPPORT SERVICES**

### **6.1 Assembly and Processing Facilities**

Wallops Island has the assembly and processing facilities described in Table 24.

*Table 24: Assembly and Payload Processing Facilities Wallops Island*

Bldg	Function	Sq. Ft.	Special Features
V-45	Assembly	4,933	10-ton bridge crane – critical
V-55	Assembly	2495	20-ton bridge crane – critical 100K Clean Room Hypergolic Fueling Capability
W-15	Assembly	5,165	One 3,936 square foot bay Door 13 feet high x 12 feet wide 3-ton overhead crane with 10-foot hook height Approved for explosives 6-ton bridge crane – non-critical
W-65	Assembly	13,255	6 bays: pyrotechnic storage rooms 6 assembly bays: approved for explosives Bay Doors: HxW crane(s) hook height (hh) Bay 1: 7 feet 10 inches x 23 feet 11 inches 2 x 10-ton bridge/20-foot hh Bay 2: 18 feet x 23 feet 11 inches / 2x7.5-ton monorail/18-foot hh 17 feet 10 inches x 23 feet 11 inches Bay 3: 17 feet 10 inches x 18 feet 11 inches / 2x3-ton monorail/19-foot hh Bay 4: 14 feet 11 inches x 15 feet 11 inches Bay 5: 14 feet 11 inches x 15 feet 1 inches; 2 x 3 ton monorail / 16 feet 5 inches hh Bay 6: 14 feet 11 inches x 23 feet 11 inches / 2x3-ton monorail/16-foot hh 14 feet 11 inches x 23 feet 11 inches
X-15	Payload processing	5,740	Door 19 feet 10 inches high and 18 feet 10 inches wide 3-ton overhead crane with 19-foot hook height Laboratory and office space 1-ton stationary electric chain hoist – non-critical 1-ton electric chain hoist – non-critical 5-ton bridge crane – non-critical

Bldg	Function	Sq. Ft.	Special Features
Y-15	Assembly	8,240	<p>1 high bay (Bay 8)</p> <p>7 other bays</p> <p>Approved for explosives</p> <p>Bay Doors: HxW Crane(s) hook height (hh)</p> <p>Bay 1 9 feet 6 inches x 17 feet 6 inches</p> <p>Bay 2 6 feet 10 inches x 8 feet</p> <p>Bay 3 6 feet 10 inches x 8 feet</p> <p>Bay 4 6 feet 10 inches x 8 feet / 3-ton monorail/7 feet 10-inch hh</p> <p>Bay 5 6 feet 10 inches x 8 feet</p> <p>Bay 6 6 feet 10 inches x 8 feet / 3-ton monorail/7 feet 10-inch hh</p> <p>Bay 7 6 feet 10 inches x 8 feet</p> <p>13 feet 7 inches x 10 feet 10 inches / 2-ton bridge/15 feet 10-inch hh</p>

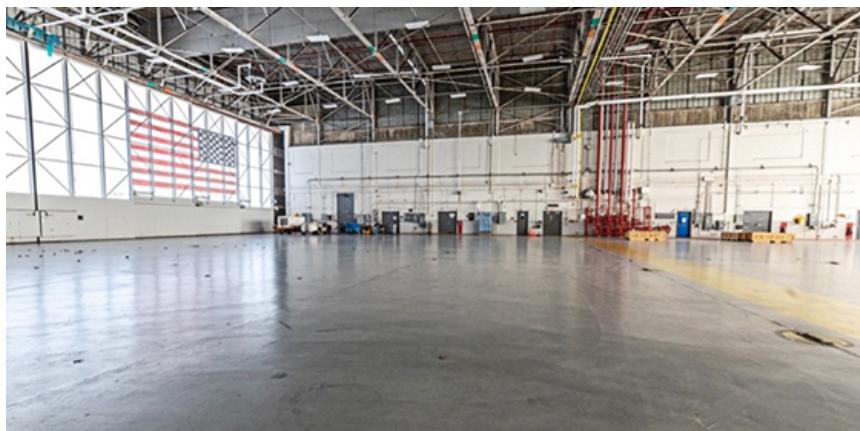
## 6.2 Aircraft Operations Hangar (Building D-1)

The Aircraft Operations Hangar, Building D-1 (see Figure 67, Figure 68 and Figure 69) has hangar, office, and shop space of varying size and location available for approved aircraft projects. Maintenance personnel should accompany project and research and development (R&D) aircraft when engaged in flight operations at Wallops.

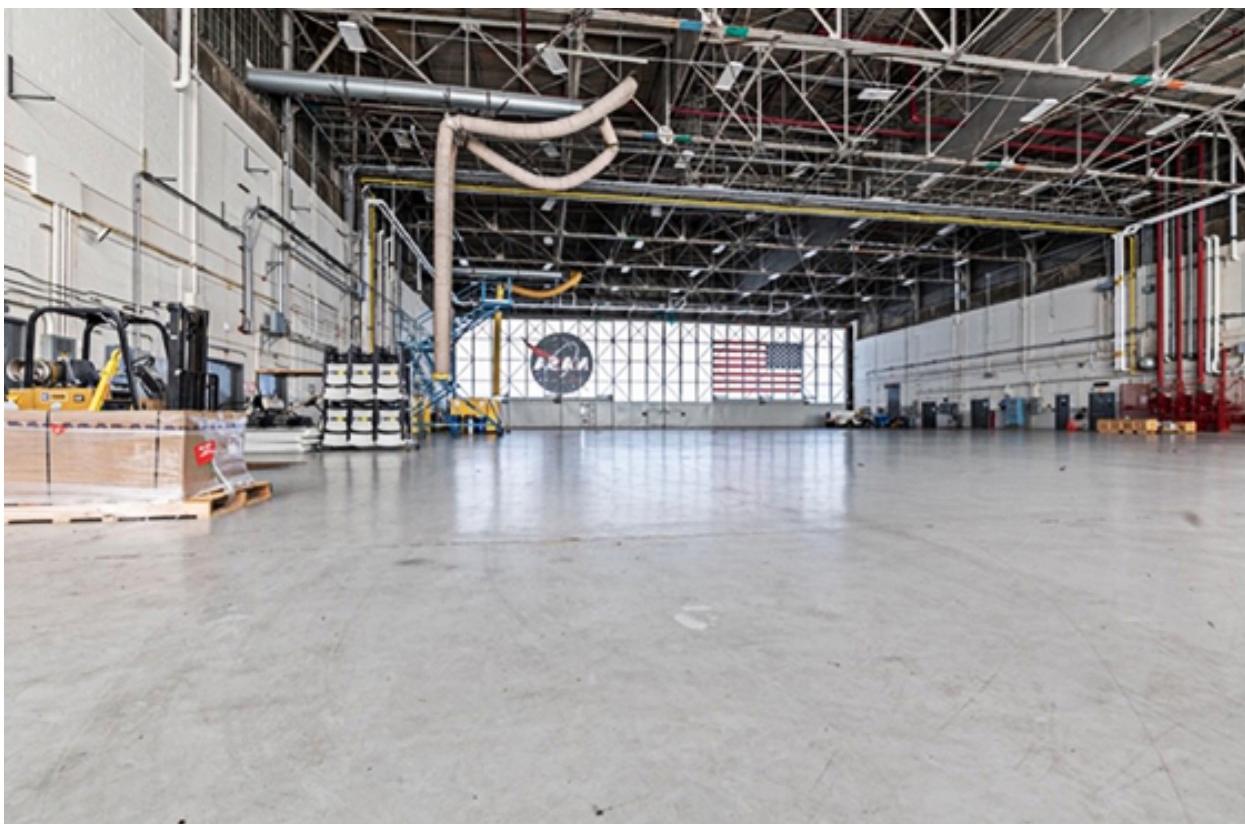
Fuel services are available for U.S. Government program aircraft during normal working hours and after hours by prior arrangement. Fuel is dispensed from trucks equipped with single point refueling fittings. The specifications for Building D-1 are shown in Table 25.



*Figure 67: Aircraft Operations Hangar (Building D-1)*



*Figure 68: Aircraft Operations Hangar (Building D-1)*



**Figure 69: Aircraft Operations Hangar (Building D-1)**

**Table 25: Building D-1 Specifications**

<b>Space:</b>	
Hangar Bay	185 feet long by 120 feet side by 40 feet high – 22,200 square feet.
Hangar Power	From 110 VAC to 460 VAC 3 phase to 200 amps
Floor Load	Aircraft rated
Adjacent Supporting Lab & Office Space	9000+ square feet
Building D-101 may be available as a “Line Shack” for ramp personnel if required.	
<b>Lifting Capacities:</b>	28-ton mobile crane
	155-ton mobile crane (ramp area only)
<b>Hangar Area Door Sizes:</b>	125 inches by 40 feet outside leading into the hangar from the west and east sides (D-1)

<b>Fluids/Gases:</b>	
Compressed Air	125 psi
Nitrogen (GN <sub>2</sub> )	4500 psi (mobile aircraft servicing cart)
ABO (Gas)	2400 psi (mobile aircraft servicing cart)
ABO (Liquid)	290-gallon dewar and 50-gallon mobile cart (pre-coordination required)
Nitrogen (GN2)	Source available up to 9000 psi
F-24 Fuel	(60,000 gallons on site), 3 fuel trucks
<b>GSE Available:</b>	
	AC and DC aircraft ground power carts
	Tugs
	Forklifts
	Navy all-bar
	Assorted tow bars (contact for type and availability)
<b>Additional Features:</b>	
	Hurricane worthiness – 120 mph
	Wash apron
	Availability – High

### 6.3 Aircraft Hangar (Building N-159)

Hangar and office space are available for approved aircraft projects and vary in size and location. Since Wallops is equipped to support only minor or limited repairs to transient aircraft, maintenance personnel should accompany project and R&D aircraft when engaged in flight operations at Wallops. The N-159 Aircraft Hangar is primarily used to support and maintain NASA aircraft. Due to the number of NASA aircraft housed in this hangar there is limited availability to support additional aircraft.

The specifications for Building N-159 are shown in Table 26:

**Table 26: Building N-159 Specifications**

<b>Space:</b>	
Hangar Bay	140 feet wide by 140 feet long by 40 feet high – 19,600 square feet
Floor Load	Aircraft rated
Adjacent Supporting Lab & Office Space	1,558 square feet
<b>Lifting Capacities:</b>	No cranes available in N-159, projects must use mobile cranes for support

<b><i>Hangar Area Door Sizes:</i></b>	
	132 feet by 35 feet outside leading into the hangar from north & south sides
<b><i>Fluids/Gases:</i></b>	
	No compressed gases or fluids are available in N-159; projects must provide their own gases and fluids
<b><i>Power:</i></b>	
	280A 208V (at 4 hangar locations)
	260A 480V (at 4 hangar locations)
	140A 120V (at 4 hangar locations)
<b><i>Additional Features:</i></b>	
	Hurricane worthiness – 120 mph
	Availability – Low

## 6.4 MARS/VCSFA

The Virginia Commercial Space Flight Authority (VCSFA), also known as ‘Virginia Space,’ is a political subdivision of the Commonwealth of Virginia. Virginia Space owns and operates the Mid-Atlantic Regional Spaceport (MARS), MARS Unmanned Aircraft Systems (UAS) Airfield, MARS Payload Processing Facility, MARS Integration and Control Facility, and soon-to-be MARS Port.

Virginia Space aims to provide and is proud to offer full-service launch and drone testing facilities for commercial, government, scientific and academic users, including the Northrop Grumman Antares vehicle (see Figure 70).

The mission of Virginia Space is to serve as a driver for Virginia’s New Economy by providing safe, reliable, and responsive space access at competitive prices, and secure facilities for testing of unmanned vehicles for integration into the National Air Space.



*Figure 70: The Northrop Grumman Antares vehicle, on its way to the commercially operated MARS launch pad*

## 6.5 UAS Airfield

The Mid-Atlantic Regional Spaceport's UAS Airfield, shown in Figure 71, conducts operations including training for first responders, student outreach including ThinSat flights, NASA Langley Research Center (LaRC) test flights, numerous 14 CFR Part 107 flights involving aerial imagery; environmental and wildlife monitoring, DoD projects and FireScout Training Detachments. This airfield services both commercial and government customers regularly.

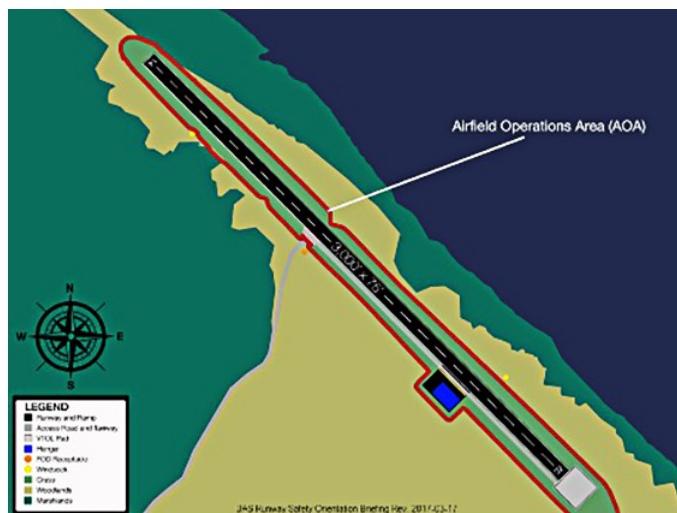


*Figure 71: MARS UAS Airfield*

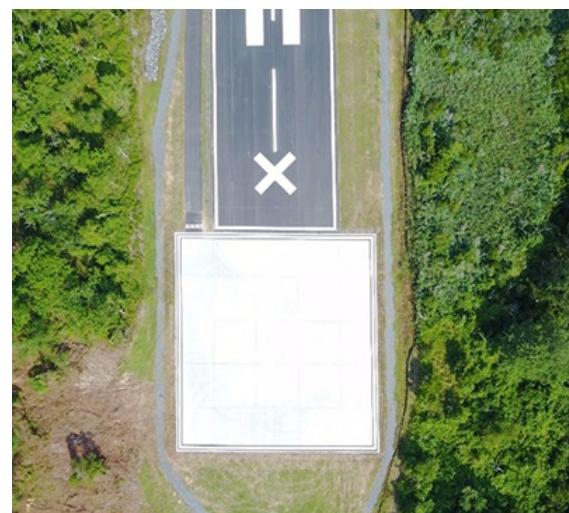
Attributes of the UAS Airfield are listed in Table 27 and shown in Figure 72 and Figure 73.

*Table 27: UAS Airfield*

<b>Location</b>	Within Special Use Airspace R-6604, partnered with the NASA Wallops Range on Wallops Island
	14/32 layout approximately .75 inland from the Atlantic Ocean
<b>Magnetic Headings</b>	135/315
<b>Geo Coordinates</b>	37°56' North Latitude, 75°28' West Longitude
<b>Airfield Elevation</b>	9 feet above Mean Sea Level



*Figure 72: 3000-foot x 75-foot UAS Runway*



*Figure 73: Concrete VTOL Pad rated to 5000 psi*

### *UAS Hangar Bay*

The UAS Hangar Bay, shown in Figure 74, has attributes as listed in Table 28.

**Table 28: UAS Hangar Bay Specs**

95 feet x 50 feet HVAC conditioned hangar
70 feet by 20 feet hangar door
Full power and communications suite
Dedicated mission-planning ready room
Fire detection system
Special use airspace and frequency management



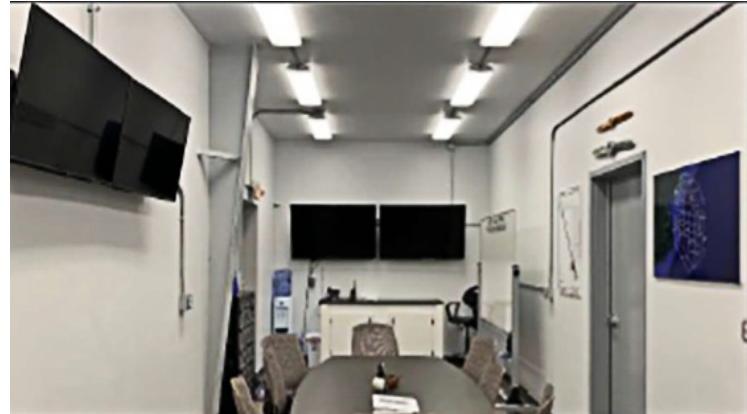
**Figure 74: MARS UAS Airfield HVAC Conditioned Hangar**

### *Ready Room Adjacent to Hangar Bay*

A ‘Ready Room’ next to the Hangar Bay (see Figure 75) includes the capabilities described in Table 29.

**Table 29: Ready Room Specs**

NASA CCTV
Weather channels
Phone lines
Closed network airfield cameras
Conference table
Work desk area
Next Generation Land Mobile Radios (NGLRM): equipped with KWAL tower communications channel and dedicated airfield operations channel VHF/UHF common traffic advisory frequency (CTAF) capable



**Figure 75: Ready Room Adjacent to Hangar Bay**

### Ramp Area

The ramp area adjacent to the UAS Airfield, as shown in Figure 76, encompasses the facilities described in Table 30.

**Table 30: Ramp Area**

*Specs*

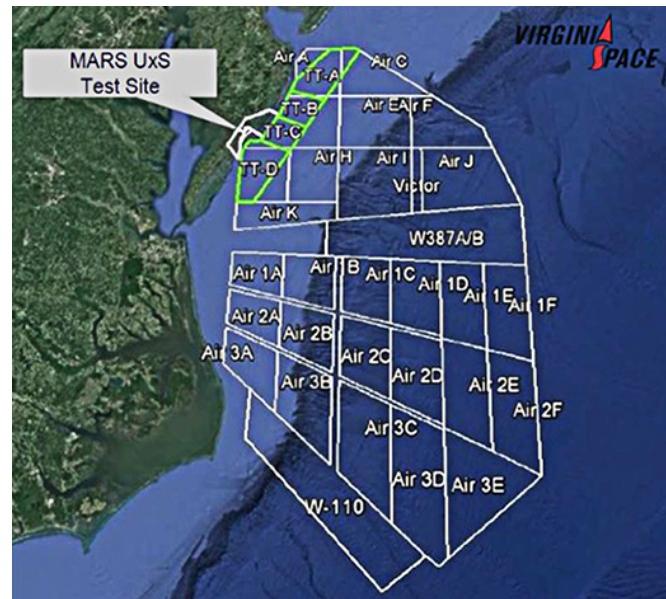
55-foot Antenna tower
Network switches with multiple cables from top to bottom, configurable
DB9, coax, Cat5 etc.
110 volts convenience power to top
240 volts at bottom
Auxiliary items
Wash-down pad capable of holding MH-60 Seahawk
550-gallon water tank
Mobile air-conditioned restroom facility



**Figure 76: MARS UAS Airfield Ramp Area**

### Direct Access to R6604 Restricted Airspace

The Special Use Airspace (SUA) access is a NASA-controlled restricted airspace R-6604 with over 300 square nautical miles (NM) of restricted airspace (see Figure 77). The Patuxent River Atlantic Test Range (ATR) has a test track A, B, C, and D, with over 1500 square NM of SUA. The Fleet Area Control and Surveillance Facility (FACSFAC) Virginia Capes Operating Area (VACAPES) have over 25,000 square NM of SUA. Virginia Capes offers DoD/government customers access to warning areas beyond the test track from surface to space including W-386, W-387 and W-72.



**Figure 77: Direct Access to R6604 Restricted Airspace**

## 6.6 MARS Payload Processing Facility



*Figure 78: MARS Payload Processing Facility*

The VCSFA Payload Processing Facility (PPF – Figure 78 shows an external overview; see Figure 79, Figure 80 and Figure 81 for views of the interior) has capabilities such as multiple segregated processing spaces, payload integration and fueling, and stage integration. The PPF building is designed to separately process the launch vehicle (LV) and spacecraft (SC). The integration area is built to ISO 8 (100K) clean room standard as well as to Intelligence Community Directive (ICD) 705. The PPF also includes multiple overhead cranes including an overhead processing, a 30-ton crane with a 60' hook height in the vertical integration area, and a dual 15-ton with a 30-foot hook height in the horizontal integration area.



*Figure 79: MARS Payload Processing Facility  
Solid Motor Processing Bay*



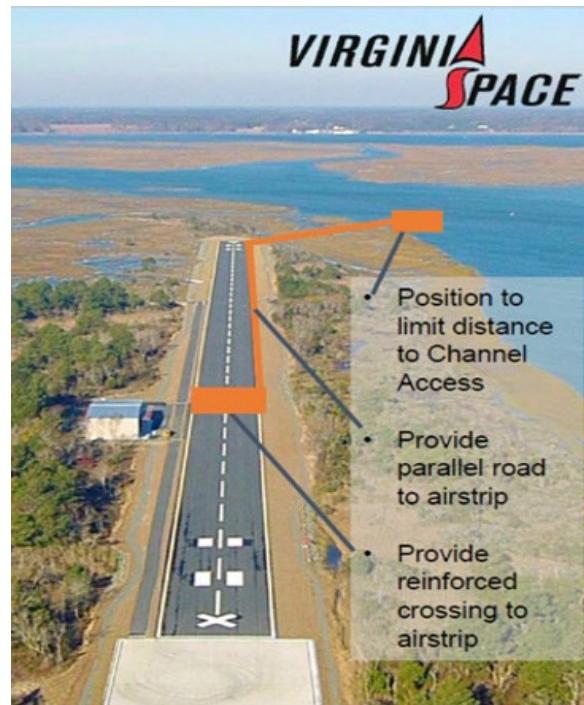
**Figure 80: MARS Payload Processing Facility Secondary Payload Processing Bay**



**Figure 81: MARS Payload Processing Facility Control Systems**

## 6.7 MARS Port

The MARS port is planned for construction between 2022 and 2024. Figure 82 shows a summary of proposed upgrades. It will provide opportunities for unmanned and intermodal research and continue science, technology, engineering and mathematics (STEM) outreach/workforce development in technical jobs. The MARS port will also permit the transportation of oversized and hazardous cargo via waterways versus rail and roads. Anticipated activities include inter-governmental test and operations with the Navy, DoD, National Oceanic and Atmospheric Administration (NOAA), NASA, state institutions, research partners, and the Federal Aviation Administration (FAA). The MARS port will enable classified advancements that improve interoperability, redundancy, and research in our nation's transportation system.



**Figure 82: UUV/USV Port Upgrade Summary**

## 6.8 Mission Operations Control Center (MOCC)

The Mission Operations Control Center (MOCC) is a \$16 million, 14,174 square-foot building on the Wallops main base, which serves as the hub for interfacing with and controlling rockets, their payloads and associated launch pad support systems during flight operations at Wallops.

## 6.9 Integration and Control Facility

The Integration and Control Facility (ICF, shown in Figure 83) construction began in November 2019 and had a Certificate of Occupancy by November 2020. It is the first facility in the Wallops Business Park and sets the standard for future commercial activities in this area. It is currently leased to Rocket Lab by the VCSFA. The integration space is used for the integration of electron launch vehicles. The facility includes a mission control room as well as an office space.



*Figure 83: Integration and Control Facility (ICF)*

## **APPENDIX A: ABBREVIATIONS AND ACRONYMS**

<i>Acronym</i>	<i>Definition</i>
ACS	Attitude Control System
ADS	Advanced Design System
ANSI	American National Standards Institute
ATR	Atlantic Test Range
BRDL	Balloon Research and Development Laboratory
CAD/CAM	Computer-Aided Design and Manufacturing
CE	Conducted Emissions
C/F	Coldfinger
CG	Center of Gravity
CNC	Computer Numerical Control
CTAF	Common Traffic Advisory Frequency
CWA	Clean Work Area
DoD	Department of Defense
EGSE	Electrical Ground Support Equipment
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESPA	Expendable Launch Vehicle Secondary Payload Adapter
ETE	End-To-End
FAA	Federal Aviation Administration
FACSFAC	Fleet Area Control and Surveillance Facility
FPGA	Field Programmable Gate Array
FTS	Flight Termination Receiver System
GPS	Global Positioning System
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HGA	High Gain Antenna
HIF	Horizontal Integration Facility
I&T	Integration And Test
I/O	Input/Output
ICD	Intelligence Community Directive
ICF	Integration and Control Facility
IMU	Inertial Measurement Unit
IRIG	Inter-Range Instrumentation Group
ISO	International Standards Organization

<i>Acronym</i>	<i>Definition</i>
ISS	International Space Station
L9EFS	Landsat 9 ESPA Flight System
LaRC	Langley Research Center
LDSD	Low-Density Supersonic Decelerator
LV	Launch Vehicle
MARS	Mid-Atlantic Regional Spaceport
MGSE	Mechanical Ground Support Equipment
MOI	Moment of Inertia
MPL	Mission Planning Lab
MPPF	Multi-Payload Processing Facility
NACA	National Advisory Council on Aeronautics
NGLRM	Next Generation Land Mobile Radio
NM	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NSROC	NASA Sounding Rocket Operations Contract
PAI	Precision Analog Input
PC	Personal Computer
PCM	Pulse-Code Modulation
PPF	Payload Processing Facility
R&D	Research and Development
RE	Radiated Emissions
RF	Radio Frequency
RGA	Residual Gas Analyzer
RS	Radiated Susceptibility
SC	Spacecraft
SP	Scavenger Plate
STEM	Science, Technology, Engineering and Mathematics
SUA	Special Use Airspace
TQCM	Thermoelectric Quartz Crystal Microbalance
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aircraft Systems
VACAPES	Virginia Capes Operating Area
VCSFA	Virginia Commercial Space Flight Authority
WASP	Wallops Arc Second Pointer
WFF	Wallops Flight Facility